A Progress Report for:

An Ecologic Study of Peat Landforms in Canada and Alaska

By

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1. Publications

Three manuscripts were submitted for publication during the past 6 months: 1) Peat landforms in northern Minnesota: vegetation, water chemistry, and developmental trends (Ecological Monographs), 2) Boreal patterned peatlands in northern Minnesota: a community profile (U.S. Fish & Wildlife Service), and 3) Groundwater flow in a bog/fen complex, Lost River peatland, northern Minnesota (Journal of Ecology).

These papers described the role of groundwater and surface runoff in controlling the water chemistry and development of peat landforms in northern Minnesota. Landsat imagery from northern Minnesota, for example, indicates that the majority of the Lake Agassiz peatlands are minerotrophic fens despite the vast peat cover and relative isolation of the peat surface from a surface source of alkalinity. Without a substantial supply of alkalinity from groundwater discharge these fens would probably have been overgrown by acidiphilic Sphagnum creating vast ombrotrophic (rain nourished) raised bogs. The Landsat imagery taken during spring break-up are particularly valuable in identifying potential zones of groundwater discharge. Such zones appear as dark strips set against a background of white snow-covered peat and mineral uplands. The three most important types of landforms associated with groundwater discharge in these peatlands are: 1) sinuous channels on the outer periphery of water tracks containing fields of tree islands, 2) anastomosing networks of channels that drain through spring fens, and 3) internal water tracks arising within large raised bog complexes. Another landform type potentially associated with groundwater discharge are lakes with degrading peat borders found in the Hudson Bay lowlands.

The discharge of groundwater at the mire surface may have occurred quite suddenly in the past as indicated by the peat stratigraphy under these

landforms. The head of the internal water tracks and spring fen channels are characterized by similar peat profiles with an upper layer of sedge fen peat overlying a thick layer of Sphagnum bog peat below. The simplest explanation for these profiles would be the sudden discharge of calcareous groundwater on the bog surface in response to a rise in the water table in the regional recharge area. Several models have been developed to reconstruct the mechanism by which hydrology interacts with vegetation processes to control the development of these peat landforms.

Two other manuscripts are nearing completion. One paper describes the vascular floras of raised bogs in eastern North America demonstrating the remarkable uniformity of the ombrotrophic flora over broad geographic regions. The bog floras were analysed by Detrended Correspondance Analysis, which separates the various bogs into well-defined regional groups. In continental regions these groups also correspond to a particular landform type enhancing the ability of the very small-scale Landsat imagery to accurately predict vegetation and water chemistry conditions on the ground. In transitional areas where the landforms are representative of two or more geographic types, such as the forested and nonforested bogs along the Albany River the DCA ordination correctly separates each bog sampled according to its respective landform type.

The other paper describes the evolution of peat landforms in the major boreal peatlands of eastern North America. The Landsat imagery is used to determine 1) the area of patterned to featureless peatlands, 2) the area of ombrotrophic bog relative to minerotrophic fen, and 3) the relative size and degree of streamlining of island landforms entirely composed of peat. Such measurements can be used to assess the role of climate, time, and hydrology in controlling the formation of peatland patterns across broad geographic regions.

2. Abstracts

Two abstracts were also accepted for presentation as papers at scientific meetings. The detection of ground water discharge in extensive peatlands by remote sensing will be presented at the IV International Congress of Ecology to be held in Syracuse on August 1Ø-16, 1986. The development of boreal peatlands in the interior of North America will be presented at the Conference on Restoration and Vegetation Succession in Circumpolar Lands to be held in Reykjavic, Iceland on September 7-13, 1986. Both papers will stress the role of hydrology in controlling the regional development of boreal peatlands and the recognition of common successional trends in the vegetation through the interpretation of peat landforms and remote sensing imagery.

3. Field Work

Preparations for field work in 1986 included a trip to the National Air Photo Library in Ottawa to survey air photos of proposed study areas near Great Slave Lake in Northwest Territories and Lake Winnipeg in northern Manitoba. The photos and Landsat imagery indicate that an important transition in the peat landforms occurs in northern Saskatchewan and northern Alberta with the appearance of peat plateaus (large bog areas underlain by permafrost) and the transition from linear to reticulate networks of ridges and pools in patterned fens. Reticulate networks generally become more common north of the Albany River and west of The Pas in western Manitoba. The largest peat plateaus, in contrast seem to be most conspicuous in the Great Slave Lake lowland.

Field trips are planned to Great Slave Lake and Lake Winnipeg during the summer of 1986. The Great Slave trip will focus on peat plateaus, reticulate

fens, and various other types of landforms recognizable on the satellite imagery. Of particular interest are ovoid island and drainage channel patterns that on the Landsat imagery appear similar to those found in the Glacial Lake Agassiz peatlands. These features will have to be field checked to determine if they are peatlands or mineral soil. Examples these landforms are present near the Mackenzie Highway and the initial field work will therefore be conducted from the road. The northern Manitoba trip will focus on reticulate fens and mire complex types similar to those in the Glacial Lake Agassiz region of Minnesota and Albany River region of the Hudson Bay lowlands. A helicopter may be used to conduct part of these investigations.

I am also seeking to return to the Albany River region to continue work on the origin of peat landforms in this region. I have insufficent funds to charter a helicopter so I have tried to share field expenses with other investigators. The object of the field research will be determine the hydrology and peat stratigraphy associated with particular types of peat landforms. If the different types of landforms are consistently associated with particular hydrological conditions (e.g. discharge, recharge of groundwater) then the analysis of the landform patterns on satellite imagery can be used to predict regional hydrological flow conditions.

Field sampling of groundwater flow patterns can be determined quickly with a new probe developed by D.I. Siegel of Syracuse University. The probe can measure upward, downward, or horizontal head gradients and can be checked against the readings measured by more traditional piezometers.

3) Analysis of Landsat Imagery

The TM imagery is exceptionally sharp and 10 x 10 inch transparencies in band 4 capture not only the larger peat landforms but also some of the much smaller patterns such as the pool networks on bogs and patterned fens.

Unfortunately the survey of peat landforms has been hampered by the absence of cloud-free scenes for important parts of the peatland regions on Glacial Lake Agassiz, Hudson Bay Lowlands, and Great Slave/Great Bear Lake lowland. Hopefully, cloud-free imagery taken during the growing season will be become available in the near future when it is still possible to include it in this investigation. Images taken during spring break-up are also desirable for identifying potential zones of groundwater discharge in the extensive peatlands of the Hudson Bay and Great Slave lowlands.

The TM imagery already acquired from NASA is being used to map of regional patterns of peat landforms across the major peatlands of central and western Canada. Aerial photographs are being used to fill in the gaps where TM imagery is unavailable because of extensive cloud cover. The older Landsat imagery has been used in the papers submitted for publication to avoid the copyright infringement with EOSTAT but these images are greatly inferior to the newer TM scenes. Only the newer TM imagery has sufficent resolution and scale to quantitatively measure changes in the peat landforms on a regional scale.

The TM images are being used to determine the regional extent of featureless peatlands relative to those that have characteristic peat landforms. This survey is focused on regions where peat covers over 75% of the regional landscape, such as portions of the Glacial Lake Agassiz region, Hudson Bay lowlands, and Great Slave Lake lowlands. The regional degree of surface patterning in these peatlands provides an important index to analyse the factors that control the formation of peat landforms.

In the Glacial Lake Agassiz basin in Minnesota the majority of the peat surface consists of featureless swamp forests, whereas toward the north the proportion of patterned landforms increases. In the Albany River region, for

example nonpatterned swamp forests are greatly restricted in area to low lying areas downslope from moraine complexes. These areas have essentially the same vegetation and water chemistry as those occurring on the bed of Glacial lake Agassiz to the south. Along the coast of James Bay, however, these nonpatterned swamp forests form an almost continuous peat cover except for raised beach ridges and occasional raised bogs. The peat cover closer to the coast is much younger then that farther inland because of its more recent emergence from the sea. The peatlands of the Glacial Lake Agassiz region are also comparatively young having originated since the mid-Holocene (4000 yrs B.P.). The influence of time as a factor in pattern formation will become clearer once the ^{14}C dates become available for the peat cores collected in the Albany River.

The role of hydrology in maintaining fen vegetation and preventing the spread of raised bogs is being examined by measuring the relative areas of bog and fen landforms in these peatlands regions from TM imagery. The water chemistry from these landforms is remarkably unifrom across broad geographic regions and therefore an estimate can be made of the regional patterns of water chemistry on the ground from the TM views of the peat landforms. A geochemical mixing model is being developed with D.R. Janecky of Los Alamos National Laboratory and D.I. Siegel of Syracuse University that predicts the degree of input of alkalinity from atmospheric versus groundwater sources. This model will be applied to the analysis of the water samples collected on the ground during the field season and the regional area of bog vs fen patterns to determine the relative input of groundwater to maintain these patterns on a regional basis.

Measurement are also being made of the size of individual bogs and water tracks across these peatland regions to determine if the variabilty of their sizes within and between different regions. The streamlining of the bog

islands, for example seems to indicate an equilibrium condition between the spread of bog-forming Sphagna and the volume of minerotrophic runoff in the surrounding water tracks. These measurements indicate a regional trend toward a progressive dissection of the raised bogs into smaller islands and water tracks toward the north.

Appendix

Papers accepted for publication

Glaser, P.H. Boreal patterned peatlands in northern Minnesota: a community profile. U.S. Fish & Wildlife Service, National Coastal Ecosystems Team.

Siegel, D.I. and P.H. Glaser. Groundwater flow in a bog/fen complex, Lost River peatland, northern Minnesota. Journal of Ecology

Papers submitted for publication

Glaser, P.H. & D.R. Janecky. Peat landforms in northern Minnesota: vegetation, water chemistry, and developmental trends. Ecological Monographs

Papers in manuscript

Glaser, P.H. Raised bogs in eastern North America: the biogeography of the vascular flora.

Glaser, P.H. The development of boreal peatlands in the interior of North America.

Glaser, P.H., J.A. Janssens, D.I. Siegel. The development of vegetation patterns and surface water chemistry in the Lost River peatland, northern Minnesota.